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(54) **SELECTED FORWARDING BETWEEN SERIALLY CHAINED DEVICES**

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H04N 7/10 (2006.01)
G06F 13/40 (2006.01)
H04N 7/08 (2006.01)

(52) **U.S. Cl.**

CPC ***H04N 7/104*** (2013.01); ***G06F 13/4022*** (2013.01); ***H04N 7/0806*** (2013.01); ***H04N 7/106*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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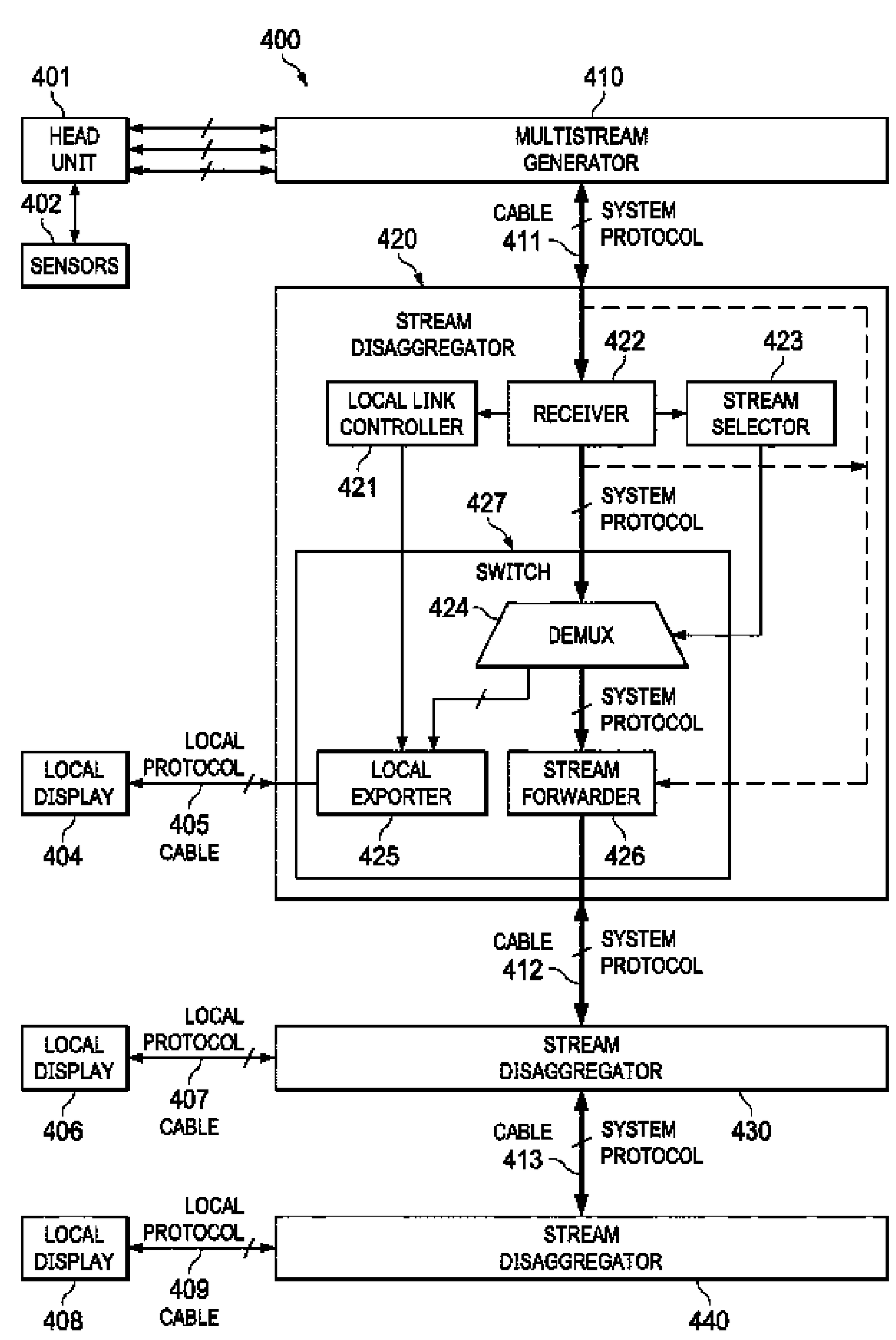
(57) **ABSTRACT**

In described examples, a receiver includes a receiver input adapted to receive input data. A selector is coupled to an output of the receiver and is configured to generate a destination indication at an output of the selector. A switch is coupled to the receiver input. The switch is adapted to generate a first transmission at a switch local output in response to an indication of the selector output and the input data. The switch is further adapted to generate a second transmission at a switch system output in response to the input data. The switch local output is adapted to be coupled to a first destination node, and the switch system output is adapted to be coupled to a second destination node.

4 Claims, 4 Drawing Sheets



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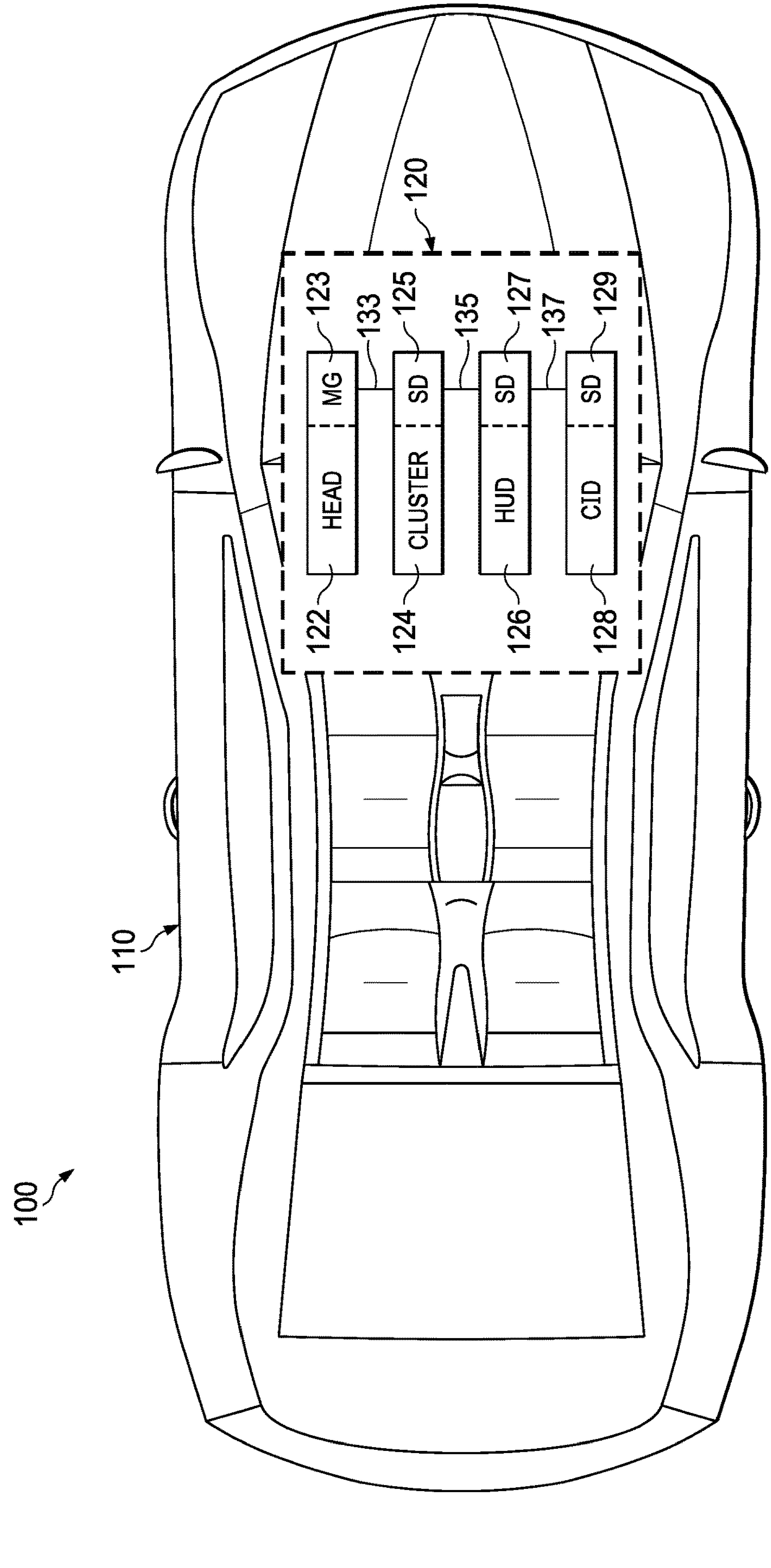

120
123
133
125
135
127
137
129
MG
SD
SD
SD
HEAD
CLUSTER
HUD
CID
122
124
126
128
110
100

FIG. 1

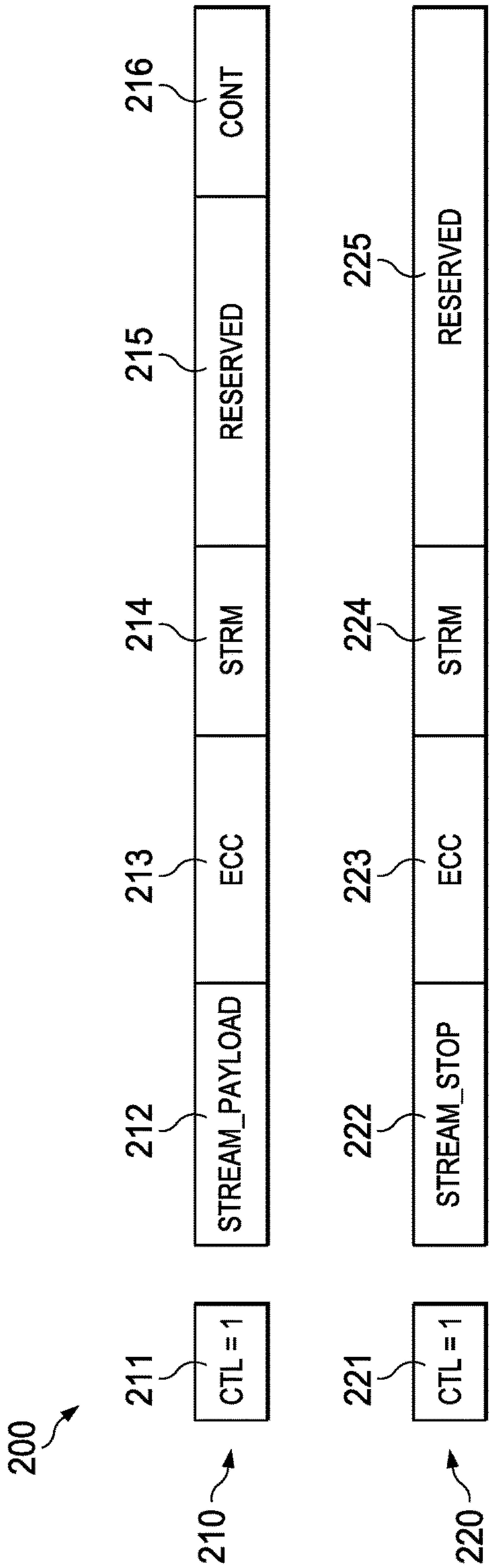

200
210
CTL = 1
211
STREAM_PAYLOAD
212
ECC
213
STRM
214
RESERVED
215
CONT
216
220
CTL = 1
221
STREAM_STOP
222
ECC
223
STRM
224
RESERVED
225

FIG. 2

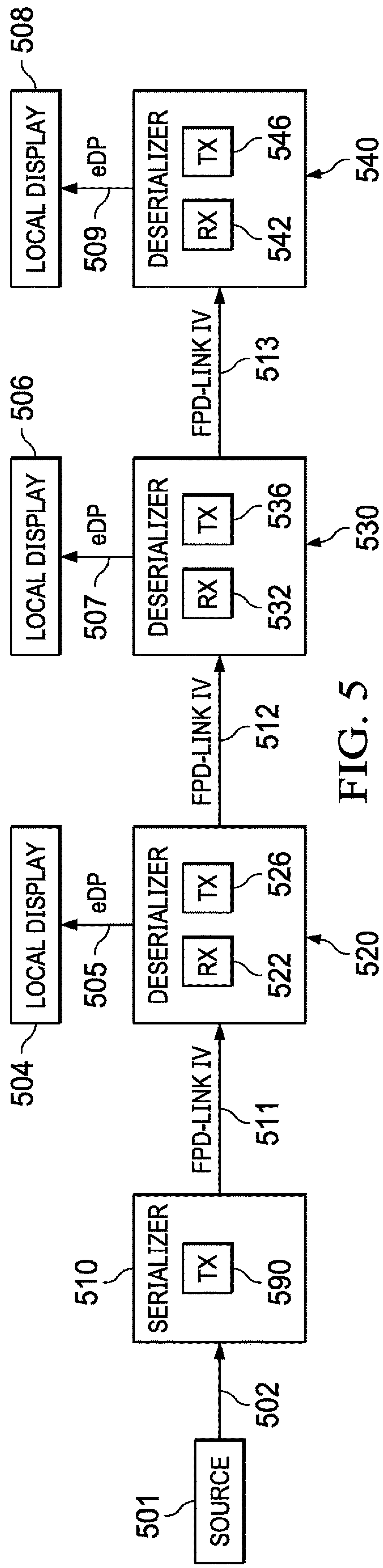

SOURCE
501
502
SERIALIZER
510
TX
590
FPD-LINK IV
511
LOCAL DISPLAY
504
eDP
505
DESERIALIZER
RX
522
TX
526
520
FPD-LINK IV
512
LOCAL DISPLAY
506
eDP
507
DESERIALIZER
RX
532
TX
536
530
FPD-LINK IV
513
LOCAL DISPLAY
508
eDP
509
DESERIALIZER
RX
542
TX
546
540

FIG. 5

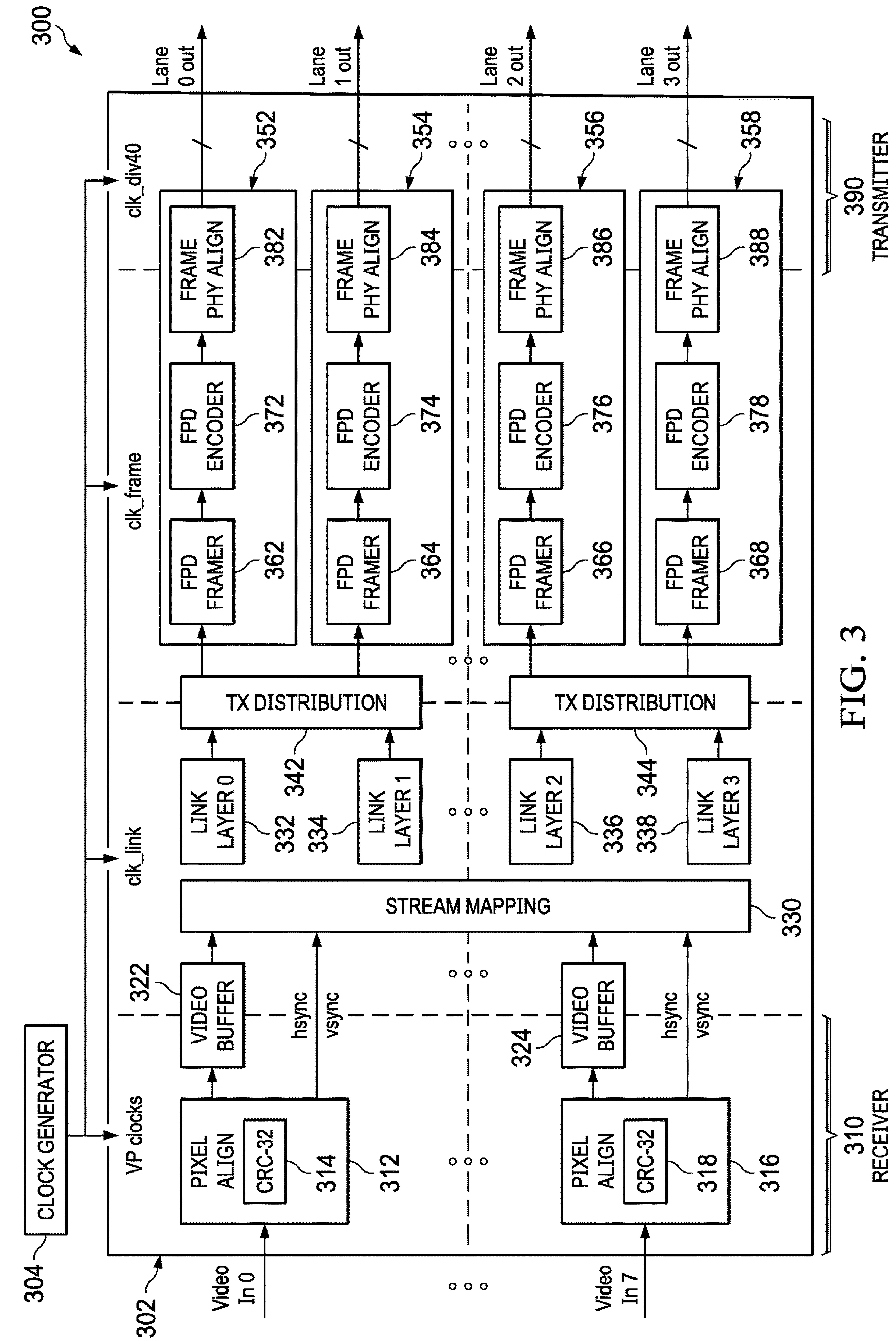
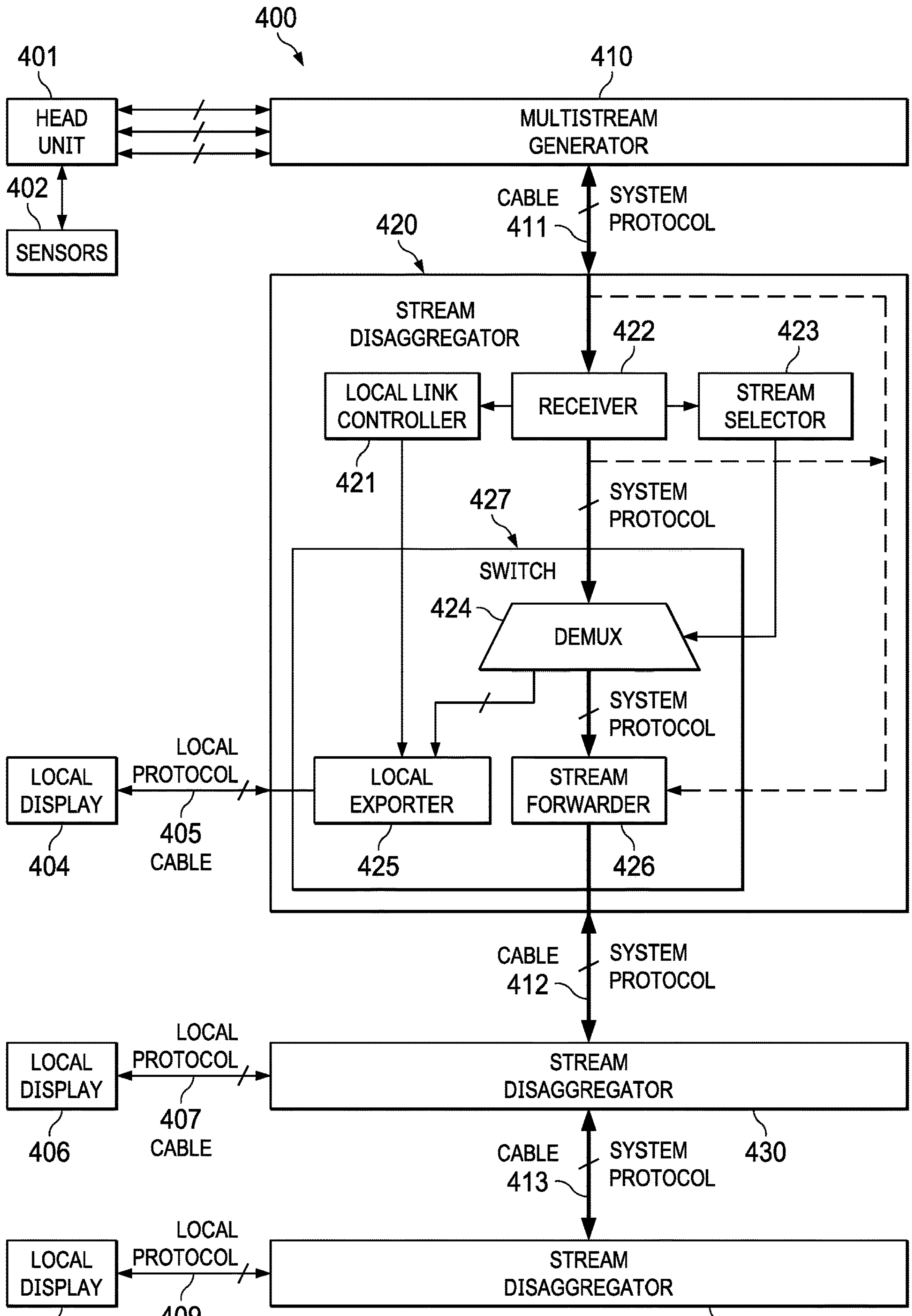

300
304
CLOCK GENERATOR
302
VP clocks
clk_link
clk_frame
clk_div40
Video In 0
Video In 7
PIXEL ALIGN
CRC-32
314
312
PIXEL ALIGN
CRC-32
318
316
VIDEO BUFFER
322
VIDEO BUFFER
324
hsync
vsync
hsync
vsync
STREAM MAPPING
330
LINK LAYER 0
332
LINK LAYER 1
334
LINK LAYER 2
336
LINK LAYER 3
338
342
344
TX DISTRIBUTION
TX DISTRIBUTION
FPD FRAMER
362
364
366
368
FPD ENCODER
372
374
376
378
FRAME PHY ALIGN
382
384
386
388
352
354
356
358
Lane 0 out
Lane 1 out
Lane 2 out
Lane 3 out
390 TRANSMITTER
310 RECEIVER

FIG. 3



400
401
HEAD UNIT
410
MULTISTREAM GENERATOR
402
SENSORS
CABLE
411
SYSTEM PROTOCOL
420
STREAM DISAGGREGATOR
422
423
LOCAL LINK CONTROLLER
RECEIVER
STREAM SELECTOR
421
427
SYSTEM PROTOCOL
SWITCH
424
DEMUX
SYSTEM PROTOCOL
LOCAL PROTOCOL
LOCAL DISPLAY
LOCAL EXPORTER
STREAM FORWARDER
405
CABLE
404
425
426
CABLE
412
SYSTEM PROTOCOL
LOCAL PROTOCOL
LOCAL DISPLAY
STREAM DISAGGREGATOR
407
CABLE
406
CABLE
413
SYSTEM PROTOCOL
430
LOCAL PROTOCOL
LOCAL DISPLAY
STREAM DISAGGREGATOR
409
CABLE
408
440

FIG. 4

SELECTED FORWARDING BETWEEN SERIALLY CHAINED DEVICES

CROSS-REFERENCE TO RELATED APPLICATION(S)

This divisional application claims priority to U.S. patent application Ser. No. 16/420,396 filed May 23, 2019, which application is incorporated herein by reference in its entirety.

BACKGROUND

In some electronic systems, various components are coupled by a physical layer that can include connectors and electrical wiring. In some applications, limits on the functionality of the various components can be constrained by the cost, size, and numbers of the connectors and/or the cost, size, and numbers of individual wires in the electrical wiring.

SUMMARY

In described examples, a receiver includes a receiver input adapted to receive input data. A selector is coupled to an output of the receiver and is configured to generate a destination indication at an output of the selector. A switch is coupled to the receiver input. The switch is adapted to generate a first transmission at a switch local output in response to an indication of the selector output and the input data. The switch is further adapted to generate a second transmission at a switch system output in response to the input data. The switch local output is adapted to be coupled to a first destination node, and the switch system output is adapted to be coupled to a second destination node.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a system diagram showing an example vehicle that includes an example system adapted to selectively forward transmissions between serially chained devices of the example system.

FIG. **2** is a diagram of example transmissions in an example system adapted to selectively forward transmissions between serially chained devices.

FIG. **3** is a block diagram of an example multistream generator adapted to aggregate input streams in an example system adapted to selectively forward transmissions between serially chained devices.

FIG. **4** is a block diagram of an example system that includes at least one stream disaggregator adapted to selectively forward transmissions between serially chained devices.

FIG. **5** is a block diagram of another example system that includes at least one stream disaggregator adapted to selectively forward transmissions between serially chained devices.

DETAILED DESCRIPTION

In the drawings, like reference numerals refer to like elements, and the various features are not necessarily drawn to scale.

Various electronic systems employ components coupled together to comprise the system. As the functionality of the system increases, the complexities of the interconnections increase. As more functionality is added to the system (e.g., in response to increased integration and processing power), the numbers of terminals of the connectors increase, which, in turn, increase the size, complexity, and/or cost of the connectors.

Some electronic systems can be installed in a transportation platform (such as an airplane or motor vehicle). Limitations in the structure of the mobile platform (e.g., due to human factors, safety considerations, and aerodynamic performance) can limit the space otherwise afforded to the connectors and cabling of an electronic system. Further, access to the connectors and cabling (e.g., for testing, replacement, and/or repair) can be limited (which can increase operating costs), such as when the electronic system is installed in a dashboard (that can include at least one airbag) of a vehicle.

An example of an electronic system that can be installed in a mobile platform is an automotive "infotainment" system, in which video data can be generated by (or otherwise transmitted by) a control unit (e.g., a head-unit or other data source). The generated video data can be transferred to multiple display panels (e.g., a heads-up display, an instrument cluster, and a center-instrument display). To send different types of display data to different displays from a control unit, various cables/connectors are arranged between the control unit and each of the different displays. A cable adapted to convey signals between two units (such as a display and a control unit) has a first connector (e.g., a first set of connectors) adapted to connect to first mating connector(s) of a first unit, a second connector (e.g., a second set of connectors) adapted to connect to a second mating connector(s) of a second unit, and a cable harness (e.g., flexible cable harness) having insulated wiring arranged to electrically couple signals (e.g., unidirectional and/or bidirectional signals) between the first and second connectors.

In an example, multiple displays can be connected to the control unit in a one-to-many configuration with the connecting cables converging upon the control unit at a single location (e.g., a surface of the control unit). For example, a master control unit can include a connector and cable pair for communicating with each slave device of the system (e.g., in a star-network topology). The convergence of the connectors and cables at the control unit creates mechanical spacing issues in which the convergence of multiple connectors located side-by-side occupy significant space in an automobile vehicle. Further, video information (e.g., such as at least one video stream) from a control unit is high-resolution data that is streamed continuously to respective displays via a respective connector/cable pair. Because of the point-to-point connections of the star topology, each video stream need not be associated with networking addresses or be otherwise identified. Conventionally, video data from a head unit that is being transferred to displays is high resolution data being streamed continuously and is not in a format that can be readily networked, as in some other data-networking applications.

As described herein, an example system is adapted to selectively forward transmissions between serially chained devices of the example system. For example, the example system can include a control unit coupled to a serial chain (e.g., one end of a serial chain) of display units. An example multistream generator can be coupled to an output of the control unit, so that the example multistream generator can encode (e.g., encapsulate) video data from multiple streams into a format adaptable to different types of displays in the serial chain (e.g., daisy-chained displays). The mechanical spacing issues of congestion due to cable/connector convergence at a control unit location can be alleviated by arranging the example system components as shown in FIG. **1**.

FIG. **1** is a system diagram showing an example vehicle that includes an example system adapted to selectively forward transmissions between serially chained devices of the example system. Generally described, the system **100** is an example system that includes a host vehicle **110**. An example multiple display system **120** can be installed in the host vehicle **110**. The example multiple display system **120** can include any number of displays in a serial chain, one end of which can be connected to a control unit.

An example multiple display system **120** can include a control unit (e.g., head unit **122**), a first display (e.g., instrument cluster display CLUSTER **124**), a second display (e.g., heads-up display HUD **126**), and a third display (e.g., center-instrument display CID **128**). The example multiple display system can include one or more head units **122**. A head unit **122** is adapted to receive sensor data (e.g., from cameras or instrumentation sensors) and generate video streams in response to the sensor data. Each head unit **122** transmits at least one generated video stream, each of which is received by the multistream generator **123**. However, the use of multiple head units increases system complexity, creates additional nodes of failure, increases costs, and occupies more space, for example, in confined areas.

The multistream generator **123** (MG) can have an input (e.g., video input) coupled to (e.g., can be included by) the head unit **122** and can have an output coupled (e.g., via cable **133**) to an input of the stream disaggregator **125**. In an example, the multistream generator **123** can receive a video stream from a respective head unit **122**. In some examples, the multistream generator **123** can receive a video stream from at least one head unit **122** (e.g., so that one or more video streams can be generated by a head unit **122** for stream aggregation by the multistream generator **123**).

The stream disaggregator **125** can have a first output (e.g., local output) coupled to (e.g., can be included by) the display CLUSTER **124**) and can have a second output (e.g., system output) coupled (e.g., via cable **135**) to an input of the stream disaggregator **127**.

The stream disaggregator **127** can have a first output (e.g., local output) coupled to (e.g., can be included by) the display HUD **126**) and can have a second output (e.g., system output) coupled (e.g., via cable **137**) to an input of the stream disaggregator **129**.

The stream disaggregator **129** (SD) can have a first output (e.g., local output) coupled to (e.g., that can be included by) the display CID **128**) and can have a second output (e.g., system output) optionally coupled (e.g., via another cable, not shown) to an input of an optional stream disaggregator (not shown) for display. Other stream disaggregators can be successively concatenated to the tail of the serial chain connecting the serially chained displays (e.g., where the tail of the serial chain is opposite to the end of the serial chain connected to the head unit **122**). (An example cabling network is described hereinbelow with respect to FIG. **4**.)

As compared against a star-topology display system for three displays (which includes three cables and respective connectors converging at a location of the control unit), the serially chained display system described herein alleviates space and mechanical constraints, (e.g., so that the constraints are reduced to the space of having a solitary connector/cable connected at the head unit **122**).

The multistream generator **123** is arranged to encode high-resolution, real-time video data (including video-associated data) into a packet format. Operation of a multistream generator is described hereinbelow with reference to FIG. **3**. The multistream generator **123** can be arranged as a serializer (e.g., which is adapted to serially output video data, where the video data can be received asynchronously by the multistream generator **123** in a serial or parallel format) and/or can be arranged to output the video data in a parallel manner. Each packet can include an identifier (e.g., stream identifier) for identifying a particular video stream being encoded and/or for identifying a destination of the packet (e.g., identifying the display to which the packet is addressed). The identifier can be parsed by a stream disaggregator in accordance with a mode (e.g., a default or programed configuration) associated with a respective stream disaggregator. Each packet is received by at least one stream disaggregator for forwarding (and/or decoding/deserializing).

A stream disaggregator (e.g., **133**, **135**, and **137**) is arranged to receive the packet (e.g., which has an identifier for indicating a destination display) and to select between a stream disaggregator first output (e.g., a local output for coupling information to a locally coupled display) and a stream disaggregator second output (e.g., a system output for forwarding information to at least one other stream disaggregator).

FIG. **2** is a diagram of example transmissions in an example system adapted to selectively forward transmissions between serially chained devices. Generally described, the transmissions **200** are example transmissions that are arranged in a packet format. The example transmissions can include streaming data for streaming video. The streaming video data can include audio data coupled to (e.g., synchronized with) the streaming video. The streaming data can include content for displaying moving and/or stationary images.

In a first example packet (such as packet **210**), the packet **210** includes a control (CTL) field **211**, a payload (e.g., STREAM PAYLOAD) field **212**, an error-correction code (ECC) field **213**, a stream/destination (STRM) field **214**, a reserved field **215**, and a continuation (CONT) field **216**.

The field **211** can indicate whether the stream payload (e.g., field **212**) includes command data or streaming data. Command data included by the field **212** can include: a start command, for example, for starting a playing of a selected video stream; a configuration command, for example, for configuring modes, selecting a particular protocol (e.g., from amongst various proprietary or industry standards) by which a particular stream disaggregator communicates with a connected local display (e.g., directed cabled local display), setting a playback channel for a particular display (e.g., for playing at least one selected stream that includes a selected STRM field **214** value); a routing command for selecting at least one stream to be routed to a local display (e.g., of a particular stream disaggregator); and/or a forwarding command for selecting at least one stream to be forwarded to another stream disaggregator (e.g., so that a first disaggregator forwards a selected stream to a second stream disaggregator that is downstream from the first stream disaggregator and a head unit). In an example, configuration data can be preprogramed (e.g., at system integration, such as at a car factory) into a particular stream disaggregator (e.g., so that configuration time is reduced) and command data can be used in operation to reprogram a given configuration (e.g., whether the given configuration is preprogramed or programed in operation).

Streaming data included by the field **212** can include video (e.g., still or moving video) information, audio information, or combinations thereof. The resolution of the streaming data can be selected to provide a video (and/or sound) quality commensurate with a particular display and/or target functionality. Streamed video data can include pixel information. An example pixel can include 8 bits of red information, 8 bits of green information, and 8 bits of blue information. The numbers of rows and columns of pixels can be selected to generate a video frame that corresponds to the capabilities of a particular display screen. A video frame can be encoded as transmission symbols and/or as compressed information for transmission and subsequent decoding by a target display. The video frames can be streamed (e.g., transmitted as a temporal sequence of video frames associated with a particular video "feed").

The field **213** includes an ECC code (e.g., for error detection and correction). The number of the bits of field **213** can be increased (e.g., from a one-bit parity bit to larger numbers of bits) to provide increasing levels of detection—and even correction—of errors that can occur in the packet **210** that is being transmitted and received. A receiver can evaluate the ECC code of a received packet against other bits of the received packet, for example, to correct a corrupted packet and/or request (e.g., by transmitting upstream) a retransmission of the original packet (e.g., the original packet data). The length of the ECC field can be selected to provide a level of performance for a particular functionality (e.g., for dashboard displays as compared against a less-critical infotainment display unit for viewing by a back-seat passenger).

The field **214** includes information that helps identify the display to which a received packet is to be routed. The number of bits in the field **214** is sufficient to uniquely identify a particular stream (e.g., video channel) and/or display (e.g., at least one display for consuming and playing back a stream associated with the received packet). In a first example: the field **214** includes sufficient bits to identify a particular stream (e.g., a channel number), where the stream disaggregators are programmed (e.g., via the herein-described configuration commands) to route the received packet to at least one display (e.g., that is set to the channel number, so that more than one display can playback the same stream). In a second example: the field **214** includes sufficient bits to identify a particular display (e.g., an instrument panel or an electronic side-view "mirror" display) upon which the particular received packet is to be displayed. In a third example: the field **214** includes sufficient bits to indicate a code for selecting a predefined routing configuration for consuming (e.g., routing to a local display) and/or forwarding the particular received packet. In a fourth example, the field **214** includes sufficient bits to include combinations (e.g., some or all combinations) of the functionality described herein for the first, second, and third examples.

The field **215** is reserved for conveying data for an undefined (e.g., unpublished or not-yet published) purpose. For example, a reserved field does not necessarily carry useful data in an earlier system but could be used to convey useful information in a later system, so that the packet length need not be changed to make room for carrying the later-implemented information. The field **215** can include sufficient bits to extensibly transmit and receive for packets having a common packet length (e.g., in accordance with a follow-on protocol standard related to at least one existing FPD standard or in accordance with a later-developed proprietary protocol).

The field **216** indicates whether the packet is the last packet in a stream. In an example where the field **216** indicates the last packet in a steam, a display consuming the packet can take an action in response to the indication that the particular received packet is the last packet in a stream. An example action (e.g., that is taken in response to the indication that the particular received packet is the last packet in a stream) can be a provisional action (e.g., a quickly reversible action) such as dimming a display selected to display a stream associated with the particular received packet. Packet transmission and forwarding is described hereinbelow with reference to FIG. **4**.

In a second example packet (such as packet **220**), the packet **220** includes a control (CTL) field **221**, a stop (e.g., STREAM STOP) field **222**, an error-correction code (ECC) field **223**, a stream/destination (STRM) field **224**, and a reserved field **225**.

The field **221** can indicate whether the stream payload includes command data (such as a stop command of field **222**). Command data included by the field **222** can include the stop command. In response to a transmitted stop command, downstream stream disaggregator(s) and display(s) identified by the field **224** can power-down, reinitialize, and/or reallocate resources previously allocated for displaying the stream associated with the received packet (e.g., the packet that includes the stop command). In an example, the field **222** can include commands for terminating operation of programmable hardware adapted to display video information (e.g., a code in the stop field **222** can indicate the instant packet is the last packet in a video stream indicated by the field **224**).

The field **223** includes an ECC code (e.g., for error detection and correction) such as a code include by the field **213**.

The field **224** is a field similar to field **214** and can include information for indicating which stream is associated with the packet and/or for indicating the display to which the packet is to be sent.

The field **225** is a field similar to field **215**. A continuation field, such as field **216**, need not be implemented in a packet that include a stop field because the presence of a stop field can be used to determine that a packet that includes a stop field is the last packet in the stream. Using the stop field to infer that the stream is to be terminated frees the space otherwise used by the continuation field in a packet having a stop field to be reserved for a potential future use (e.g., a future use for an arbitrary purpose).

FIG. **3** is a block diagram of an example multistream generator adapted to aggregate input streams in an example system that is adapted to selectively forward transmissions between serially chained devices. The multistream generator **300** is an example multistream generator that can be arranged on a substrate **302**. The multistream generator **302** includes an input (e.g., a receiver **310**) that is adapted to receive at least one video stream from a selected head unit and an output (e.g., a transmitter **390**) that is adapted to forward packetized video stream(s) to a first stream disaggregator. The packetized video streams can be generated (e.g., sourced) by a video source (such as a digital camera) in accordance with a MIPI (mobile industry peripheral interface) camera serial interface (CSI). The video sources for generating the example video 0 through video 7 streams can include sensors (e.g., sensors **402**), which can include various cameras such as backup or side-view cameras, where each camera can be arranged to generate a respective video stream. The video sources for generating the example video 0 through video 7 streams can also include the head unit (e.g., head unit **401**) itself, which can generate, in response to sensors such as sensors **402**, at least one video stream for display (as described hereinbelow with respect to FIG. **4**).

In one example, the clock generator **304** is arranged on the substrate **302** and is adapted to generate clock signals such as video pixel clocks (VP clocks), video link layer clocks (vclk_link), frame clocks (clk_frame), and lane clocks (clk_div40). In some examples, some of the clock signals can be generated by circuitry not included on the substrate **302**. Moreover, the architecture of the multistream generator is scalable (e.g., by powers of two), so that the multistream generator can aggregate a selected number (e.g., eight or more) of video streams (which can be addressed by including a sufficient number of bits in field **214** and field **224**). In some examples, the receiver can include a transmitter, so that information can be transmitted (e.g., in a second, opposite direction) from an example receiver **310**. The multistream generator **300** can be adapted transfer data bidirectionally (e.g., at 165 megabits per second upstream or at 13 gigabits per second downstream), where an example of bidirectional transmission/reception of transferred data is described in U.S. Pat. No. 9,363,067, issued Jun. 7, 2016, entitled "Data Signal Transceiver Circuitry for Providing Simultaneous Bi-Directional Communication Via a Common Conductor Pair," the entirety of which is incorporated herein by reference.

For a first video stream (e.g., Video In 0) in the example multistream generator **300**, a pixel aligner **312** is adapted to sample a first video transmission, to align (e.g., synchronize) the sampled data with an internal clock (e.g., a VP clock) of the multistream generator **300**, and to generate horizontal synchronization (hsync) and vertical synchronization (vsync) information (e.g., for identifying pixel location of received pixel data). The sampled data is validated by checking for errors (and correcting, if possible) by 32-bit cyclical redundancy checker (CRC) **314**. The validated information is stored in the video buffer **322** and is temporally associated with hsync and vsync information, so that, for example, start and stop packets can be respectively associated with the beginning and the end of a video frame to be displayed. The video stream can be received (e.g., from a head unit) as a serial or parallel stream, accessed from system memory (e.g., frame memory), and/or transmitted/accessed by combinations thereof.

The stream mapper **330** is adapted to receive stream (e.g., Video In 0 stream) information from the video buffer **322** and the associated hsync and vsync signals. In response to the video buffer **322** information and the associated hsync and vsync signals, the stream mapper **330** is configured to associate a particular video stream with a particular display (e.g., by setting the value of a STRM field such as field **214** or field **224**).

The lane-0 link layer **332** is arranged to generate signals (for example) adapted to control physical layer parameters for transmitting data on lane-0 in accordance with a system protocol (e.g., FPD protocol, which is described hereinbelow). The lane-1 link layer **334** is arranged to generate link control signals (for example) adapted to control physical layer parameters for transmitting data across lane-1 in accordance with a system protocol. The link control signals can be generated in synchronization with (e.g., in response to) the video link layer clocks.

Packets from a particular stream (e.g., Video In 0 stream) can be transmitted across either lane-0 or lane-1 in response to an assignment made by the transmission distributor (TX distributor) **342**. The TX distributor **342** can allocate at least one transmission lane, so that pixels of a video frame can be transmitted at a rate sufficient to fulfill frame rates of the display indicated by the STRM field. A first output of the TX distributor **342** is coupled to transfer lane-0 data to an input of the framer **352**, and a second output of the TX distributor **342** is coupled to transfer lane-1 data to an input of the framer **354**. The pixels of a video frame can be transmitted in synchronization with a frame clock. In some examples, a particular lane can be associated with a respective display (e.g., as a system design choice), so that a video stream can be associated with (e.g., forwarded to) a respective display. In some examples, lanes can be dynamically assigned on the basis of network traffic, so that a lane can carry different video streams (e.g., where a stream disaggregator is adapted to associate received packets of a particular video stream with a particular display and, in response, to forward/transmit packets of a given video stream towards the correct display).

The framer **352** and framer **354** are adapted to generate transmission frames in accordance with a system protocol, such as a low-voltage differential-signaling (LVDS) protocol. The system protocol can be an LVDS standard, such as a flat-panel display link (FPD) protocol (e.g., FPD-Link I, FPD-Link II, FPD-Link III, and any follow-on standard related to at least one existing FPD standard). The system protocol can also include a "sub-LVDS standard," current-mode and/or voltage mode drivers/receivers, and other such low power, high-speed signaling protocols (including a gigabit multimedia serial link—GMSL). The FPD framer **362** is adapted to align data for transmission within a transmission frame, the FPD encoder **372** is adapted to encode the aligned data as symbols for transmission within the transmission frame, and the FPD frame physical aligner (FRAME PHY ALIGN) **382** is adapted to buffer the encoded symbols for synchronous transmission (e.g., as clocked by a lane clock) by transmitter **390** across lane-0. The FPD framer **364** is adapted to align data for transmission within a transmission frame, the FPD encoder **374** is adapted to encode the aligned data as symbols for transmission within the transmission frame, and the FPD frame physical aligner (FRAME PHY ALIGN) **384** is adapted to buffer the encoded symbols for synchronous transmission by transmitter **390** across lane-1. The encoded symbols can be decoded, for example as described hereinbelow, by a receiver such as receiver **422** and encoded by a stream forwarder (e.g., stream transmitter) such as stream forwarder **426**.

For a second video stream (e.g., Video In 7) in the example multistream generator **300**, a pixel aligner **316** is adapted to sample a video transmission, to align the sampled data with an internal clock of the multistream generator **300**, and to generate horizontal synchronization (hsync) and vertical synchronization (vsync) information. The sampled data is validated by checking for errors by 32-bit cyclical redundancy checker (CRC) **318**. The validated information is stored in the video buffer **324** and is temporally associated with hsync and vsync information, so that, for example, start and stop packets can be respectively associated with the beginning and the end of a video frame to be displayed.

The stream mapper **330** is adapted to receive stream (e.g., Video In 7 stream) information from the video buffer **324** and the associated hsync and vsync signals. In response to the video buffer **324** information and the associated hsync and vsync signals, the stream mapper **330** is configured to associate a particular video stream with a particular display (e.g., by setting the value of a STRM field such as field **214** or field **224**).

The lane-2 link layer **336** is arranged to generate signals (for example) adapted to control physical layer parameters for transmitting data on lane-2 in accordance with a system protocol. The lane-3 link layer **338** is arranged to generate signals (for example) adapted to control physical layer parameters for transmitting data across lane-3 in accordance with a system protocol.

Packets from a particular stream (e.g., Video In 7 stream) can be transmitted across either lane-2 or lane-3 in response to an assignment made by the transmission distributor (TX distributor) **344**. The TX distributor **344** can allocate at least one transmission lane, so that pixels can be transmitted at a rate sufficient to fulfill frame rates of the display indicated by the STRM field. A first output of the TX distributor **344** is coupled to transfer lane-2 data to an input of the framer **356**, and a second output of the TX distributor **344** is coupled to transfer lane-1 data to an input of the framer **358**.

The framer **356** and framer **358** are adapted to generate transmission frames in accordance with a system protocol, such as a low-voltage differential-signaling (LVDS) protocol. The system protocol can be an LVDS standard, such as the fourth revision of the flat-panel display link (FPD) protocol. The FPD framer **366** is adapted to align data for transmission within a transmission frame, the FPD encoder **376** is adapted to encode the aligned data as symbols for transmission within the transmission frame, and the FPD frame physical aligner (FRAME PHY ALIGN) **386** is adapted to buffer the encoded symbols for synchronous transmission by transmitter **390** across lane-2. The FPD framer **368** is adapted to align data for transmission within a transmission frame, the FPD encoder **378** is adapted to encode the aligned data as symbols for transmission within the transmission frame, and the FPD frame physical aligner (FRAME PHY ALIGN) **388** is adapted to buffer the encoded symbols for synchronous transmission by transmitter **390** across lane-3.

Other video inputs (e.g., Video In 2 through Video In 6) and lane outputs (e.g., Lane-4 through Lane-15) and circuitry can be included, so that system bandwidth is sufficient to handle (for example) larger numbers of displays (e.g., for instrumentation, side and rear views, navigation, and infotainment systems for passengers) and/or increased resolutions. As described hereinbelow with reference to FIG. **4**, the output (e.g., multistream output) is coupled to at least one stream disaggregator for coupling a selected video stream to the respective local display. A local display need not be coupled to any stream disaggregator, although cabling requirements (e.g., numbers of connectors, cables, and/or conductors) in systems with multiple displays and video streams are increased for cabling a local display not coupled to a stream disaggregator.

FIG. **4** is a block diagram of an example system that includes at least one stream disaggregator adapted to selectively forward transmissions between serially chained devices. For example, the system **400** is an example system that includes a head unit **401**, a multistream generator **410**, a stream disaggregator **420** (e.g., coupled locally to local display **404** via cable **405**), a stream disaggregator **430** (e.g., coupled locally to local display **406** via cable **407**), and a stream disaggregator **440** (e.g., coupled locally to local display **408** via cable **409**). The stream disaggregators **420**, **430**, and **440** can be adapted transfer data bidirectionally (e.g., at 165 megabits per second upstream or at 13 gigabits per second downstream).

In an example, the head unit **401** is coupled to receive sensor information from sensors **402**. The sensors **402** can be a suite of sensors associated with electronic systems of a vehicle (e.g., vehicle **110**). Such sensors can include sensors adapted to sense positions of driver controls (e.g., gear shift, lights, steering wheel, turn signal lever, and other controls), vehicle attributes (e.g., speed, gas level, temperature, fuel flow, tire pressure, seat belts, and other attributes), and positioning (e.g., radar, satellite navigation, cameras, lane and curb sensors, and other relational information). The head unit **401** is adapted to generate output information (e.g., video information) in response to the sensor information. Additional head units **401** can be coupled various sensors **402** and the multistream generator **410**.

The head unit **401** is adapted to generate video information for display on the local display **404** (e.g., which can be a CLUSTER **124**), the local display **406** (e.g., which can be a heads-up display HUD **126**), and the local display **408** (e.g., which can be a center-instrument display CID **128**). For example, the head unit can generate: a first video stream of a vehicle dashboard in operation (e.g., for display on a display panel for replacing mechanical gauges); a second video stream for a HUD (e.g., to display navigation information on a virtual screen on a windshield); and a third video stream for a CID (e.g., to display real-time images from a rearward-facing backup camera). The head unit **401** is adapted to output the video streams as individual bit streams, for example.

The multistream generator **410** is a multistream generator such as the multistream generator **300**, described hereinabove. The multistream generator **410** is coupled to the video outputs (e.g., each of the video outputs) of the head unit **401** and is adapted to combine independent video streams (e.g., of at least two) of the video streams received from the head unit **401** into a unified (e.g., multistream) video stream using a system protocol. The multistream generator is adapted to packetize information from the unified video stream (which includes information of at least two video streams, for example) and to transmit the unified video stream (multi stream). Accordingly, the multistream generator is arranged as a source node of the unified video stream.

The individual packets (generated by the multistream generator) each include an identification field, such as a STRM identifier that can identify a selected display (e.g., addressed display and/or addressed node) as the destination of the packet. The multistream generator **410** is adapted to couple the encoded packets to a source output (e.g., of a source node) of the multistream generator **410**. A first cable (**411**) is connected between the multistream generator **410** (e.g., source node) and a first stream disaggregator (e.g., stream disaggregator **420**). The first cable includes conductors (and associated insulators/shielding) sufficient to carry information for all lanes (e.g., at least one lane) over which video information is transmitted.

The stream disaggregator **420** includes a local link controller **421**, a stream input (such as receiver **422**), a stream selector **423**, a demultiplexer (DEMUX) **424**, and a transmitter **427** (which includes a local exporter **425** and a stream forwarder **426**). The receiver **422** can comprise a physical layer receiver, the local exporter **425** can comprise a physical layer driver, and the stream forwarder **426** can comprise a physical layer driver. The receiver **422** has a receiver output. The receiver **422** has a receiver input adapted to receive input data (e.g., the unified video stream) from an output of a source node (e.g., the multistream generator **410**). The input data can be (and/or include) an incoming packet that includes an identification field, wherein the incoming packet is transmitted by the source node. The input data can be received as serial or parallel data. The input data is received in accordance with a system protocol (e.g., an FPD protocol) that is different from the local protocol (e.g., an eDP protocol, described hereinbelow).

The stream selector **423** includes a selector output. The stream selector **423** is coupled to a receiver output (e.g., of the receiver **422**), and the stream selector **423** is configured to generate a destination indication at the selector output (e.g., of the stream selector **423**). For example, the stream selector **423** is adapted to monitor the receiver **422** for received transmissions (e.g., packet **210** and packet **220**) for STRM field contents (e.g., which can include functional data) and to program the demultiplexer (DEMUX) **424** in response. In an example, the stream selector **423** is adapted to generate the destination indication in response to the identification field (the stream selector **423** is optionally adapted to receive an identification field.

The switch **427** includes a switch local output and a switch system output. The switch **427** is coupled to the output of the receiver **422** (or optionally coupled to the input of the receiver **422**) and is adapted to generate a transmission (e.g., output signal) at the switch local output (e.g., a first output of the switch) in response to an indication of the stream selector **423** output and the input data, and is adapted to generate a transmission at the switch system output in response to the input data. The switch local output is adapted to be coupled to a first destination node, and the switch system output is adapted to be coupled to a second destination node. For example, the switch **427** is adapted to generate, in response to the identification field, an output packet adapted to be transmitted at the switch local output (e.g., the local exporter **425**) when, for example, the identification field indicates that the packet is to be exported to the local display **404**. In one example, the switch **427** is adapted to route, in response to the destination indication, the input data to the switch system output (e.g., the stream forwarder **426**) when, for example, the destination indication at the output of the stream selector **423** indicates that the packet is to be forwarded to another display (e.g., that the packet is not to be exported to the local display **404**). In another example, the switch **427** forwards (e.g., transmits) all input data received by the stream disaggregator **420**, where the input data is coupled from the receiver input **422** (where the coupling can include coupling the input data through the receiver **422** itself and the receiver **422** output), so that a transmission at the switch system output is generated by the switch **427** in response to the input data (e.g., irrespective of the stream field **214** and **224** contents).

The demultiplexer **424** includes a first output that is adapted to be coupled to a first destination node, and the demultiplexer **424** includes a second output that is adapted to be coupled to a second destination node. For example, the demultiplexer **424** includes a first output that is adapted to be coupled via the local exporter **425** to the local display **404**. The first destination node is a local (e.g., local to the stream disaggregator **420** instance) node address that can be associated with at least one display node address. In the example, the demultiplexer **424** includes a second output that is adapted to be coupled via the stream forwarder **426**, the cable **412**, and the stream disaggregator **430** to the local display **406** (for example). The second destination node is a nonlocal node address can be associated with a display node address that indicates a node address other than a node address associated with the first destination node. The node addresses can be logical addresses of the various display nodes, whereas the stream field contents identify a particular video stream (which, for example, can be received selectively received by one or more displays having different logical addresses). A stream selector can be dynamically programmed (e.g., in response to a received control packet) to direct a selected video stream to the local display associated with the stream selector. The stream forwarder **426** is coupled to the switch system output, and the stream forwarder is adapted to transmit in accordance with the system protocol.

In an example, the demultiplexer **424** is adapted to couple (e.g., by switching), in response to the destination indication, the incoming packet to the first output of the switch and the second output of the switch. In an example, the demultiplexer **424** is adapted to generate, in response to the identification field, a packet at a selected one of the at least the first output of the switch and the second output of the switch. In an example, the demultiplexer **424** is adapted to generate a packet destination indication in response to an identification field of the incoming packet.

The local link controller is a local controller coupled to the switch local output, wherein the switch local output is adapted for transmitting to a display. The local link controller **421** is adapted to monitor the transmissions (e.g., packet **210** and packet **220**) received by the receiver **422** for commands (e.g., functional data). The local link controller **421** is adapted to control a transmission of packets from the switch local output in accordance with a local protocol (e.g., which is a protocol that is different from the system protocol).

The local exporter **425** is coupled to the first output of the demultiplexer **424**, wherein the local exporter **425** includes an exporter output adapted for coupling to a display. For example, the first output of the demultiplexer **424** is coupled to an input of the local exporter **425**. An exporter output of the local exporter **425** can be coupled (e.g., connected) to the local display **404**.

The output of the local exporter **425** includes a local protocol. In an example, the local protocol is a display port protocol such as the Video Electronics Association of America (VESA) embedded DisplayPort (eDP) standard. Accordingly, the input data can be received by the receiver **422** in accordance with a system protocol (e.g., FDP) that is different from at least one local protocol. Other display port protocols that can be supported as local protocols include: the DisplayPort (DP); the open liquid crystal display interface (OpenLDI); and the mobile industry processor interface (MIPI) display serial interface (DSI) and camera serial interface (CSI). A first local protocol (e.g., **405**) of a first display (e.g., **404**) can be a different protocol from a second local protocol (e.g., **407**) of a second display (e.g., **406**).

The stream disaggregator **420** can be programmed to operate in accordance with a protocol associated with the particular display locally coupled to the local exporter **425**. For example, the multistream generator **410** can configure the stream disaggregator **420** by transmitting a start command to the local link controller **421** that includes an indication of the selected protocol. The indication of the selected protocol can be included within a stream payload **212**, for example. In an example system, a first stream disaggregator (e.g., **420**) is adapted to select a first local protocol (e.g., **405**) and a second stream disaggregator (e.g., **430**) is adapted to select a second local protocol that is a different protocol from the first local protocol.

In an example system with two displays, a first cable (e.g. **411**) is coupled between the output of the multistream generator **410** and the input of the first stream disaggregator **420**, and a second cable (e.g., **412**) is coupled between the second output of the first stream disaggregator **420** and the input of the second stream disaggregator **430**. In the example system with two displays, received packets (e.g., encoded packets) of a first video stream are transmitted across the first cable (e.g., via a first switch local output) to the first display, and received packets (e.g., encoded packets) of a second video stream are transmitted across the first cable and the second cable (e.g., via a first switch system output and a second switch local output) to the second display.

In an example with at least two displays, the stream disaggregator **430** can include: a second receiver having a second receiver output, and having a second receiver input adapted to receive second input data from the first switch local output; a second selector having a second selector output, wherein the second selector is coupled to the second receiver, and wherein the second selector is configured to generate a second destination indication at the second selector output; and a second switch having a second switch local output and a second switch system output, wherein the second switch is coupled to the second receiver, and wherein the second switch is adapted to generate a transmission at the second switch local output in response to an indication of the second selector output and the second input data, wherein the second switch is adapted to generate a transmission at the second switch system output in response to the second input data.

In the example system with at least two displays, the stream disaggregator **430** can further include: comprising a second local controller coupled to the second switch local output, wherein the second switch local output is adapted for transmitting to a second display, and wherein the second local exporter is arranged to transmit data to the second display in response to a start command of a packet that includes the second destination indication as indicating the second display.

In another example system with at least two displays: a head unit is adapted to generate at least two video streams at an output of the head unit; and a multistream generator is coupled to the output of the head unit and is adapted to generate encoded packets that include information from the at least two video streams and to transmit the encoded packets to the source output, wherein the input data includes a packet from one of the at least two video streams. The encoded packets can be encoded by an encoder such as FDP encoder **372**, **374**, **376**, and **378**, and the encoded packets can be decoded by a receiver (e.g., receiver **422** of a downstream stream disaggregator, for example).

In an example system with at least two displays, the system includes: a head unit adapted to generate at least two video streams; a multistream generator coupled to the head unit, and adapted to generate encoded packets that comprise an identification field and that include information from the at least two video streams, and to couple the encoded packets to an output of the multistream generator; a first stream disaggregator having a first stream input coupled to the output of the multistream generator, the first stream disaggregator having a first output adapted to couple in accordance with a first local protocol a received encoded packet to a first display in response to an identification field of the received encoded packet indicating a node address of the first display, and the first stream disaggregator having a second output adapted to forward the received encoded packet in response to the identification field of the received encoded packet indicating a node address of other than a first display; and a second stream disaggregator having a second stream input coupled to the second output of the first stream disaggregator, the second stream disaggregator having a first output adapted to couple in accordance with a second local protocol the received encoded packet to a second display in response to an identification field of the received encoded packet indicating a second display node, and the second stream disaggregator having a second output adapted to forward the received encoded packet in response to an identification field of the received encoded packet indicating a node address other than a second display node address. The example system can further comprise: a third stream disaggregator having a third stream input coupled to the second output of the second stream disaggregator, the third stream disaggregator having a first output adapted to couple the received encoded packet to a third display in response to an identification field of the received encoded packet indicating a third display node address, and the third stream disaggregator having a second output adapted to forward the received encoded packet in response to an identification field of the received encoded packet indicating a node address other than a third display node address. The example system can further comprise: a first cable coupled between the output of the multistream generator and the first stream input; and a second cable coupled between the second output of the first stream disaggregator and the second stream disaggregator, wherein encoded packets of a first video stream are transmitted across the first cable to the first display, and wherein encoded packets of a second video stream are transmitted across the first cable and the second cable to the second display. In the example system, the first local protocol can be a different protocol from the second local protocol.

An example method for networking a multiple display system can include operations such as: transmitting, to a first display in response to an identification field of the received encoded packet indicating a node address of the first display, a first transmission including information of a received encoded packet; forwarding, in response to the identification field of the received encoded packet indicating a node address other than a first display node address, a second transmission including information of the received encoded packet; transmitting, to a second display in response to an identification field of the received encoded packet indicating a second display, a third transmission including information of the received encoded packet; and forwarding, in response to an identification field of the received encoded packet indicating a node address other than a second display node address, a fourth transmission including information of the received encoded packet. When the received encoded packet is a first encoded packet, the example method can further include: generating the first encoded packet in response to information received from a first video stream, and generating a second encoded packet in response to information received from a second video stream; transmitting the first encoded packet of the first video stream across a first cable to the first display; and transmitting the second encoded packet of the second video stream across the first cable and a second cable to the second display. The example method can further include: generating the first video stream in response to sensors of a vehicle that includes the first and second displays.

In an example system with three displays, a first cable (e.g. **411**) is coupled between the output of the multistream generator **410** and the input of the first stream disaggregator **420**, a second cable (e.g., **412**) is coupled between the second output of the first stream disaggregator **420** and the input of the second stream disaggregator **430**, and a third cable (e.g., **413**) is coupled between the second output of the second stream disaggregator **430** and the input of the third stream disaggregator **440**. In the example system with three displays, received encoded packets of a first video stream are transmitted across the first cable (e.g., via a first switch local output) to the first display, received encoded packets of a second video stream are transmitted across the first cable and the second cable (e.g., via a first switch system output and a second switch local output) to the second display, and received encoded packets of a third video stream are transmitted across the first cable, the second cable, and the third cable (e.g., via a first switch system output, a second switch system output and a third switch local output) to the third display.

In accordance with the examples described herein, additional displays and video streams can be added to a multiple display unit without (for example) increasing the number of cables connected to (e.g., physically connected to) the head unit **401** and/or the multistream generator **410**.

FIG. **5** is a block diagram of another example system that includes at least one stream disaggregator adapted to selectively forward transmissions between serially chained devices. For example, the system **500** is an example system that includes a source **501**, a serializer **510** (coupled to source **501** via cable **502**), a deserializer **520** (e.g., coupled locally to local display **504** via cable **505**), a deserializer **530** (e.g., coupled locally to local display **506** via cable **507**), and a deserializer **540** (e.g., coupled locally to local display **508** via cable **509**).

The cables **511**, **512**, and **513** each include physical media, through which a system protocol (e.g., system bus) is implemented. The system protocol can be either unidirectional or bidirectional. In an implementation of a bidirectional system protocol: a first bidirectional serial link is established between serializer **510** and deserializer **520** across cable **511** (which is coupled between the serializer **510** and deserializer **520**); a second bidirectional serial link is established between deserializer **520** and deserializer **530** across cable **512** (which is coupled between the deserializer **520** and deserializer **530**); and a third bidirectional serial link is established between deserializer **530** and deserializer **540** across cable **513** (which is coupled between the deserializer **530** and deserializer **540**).

The bidirectional serial link can be either asymmetric or symmetric. An example asymmetric bidirectional link includes an upstream speed (e.g., for bit traffic directed towards the serializer **510**) that is 165 megabits per second and includes a downstream speed (e.g., for bit traffic directed away from the serializer **510**) that is 13 gigabits per second. The asymmetric speeds allow high resolution video to be transmitted downstream at high bit rates (e.g., for transmitting various high-resolution video streams to selected displays), while still allowing a robust bidirectional system control and communication link between devices. An example asymmetric bidirectional link includes symmetric data speeds, so that data can be transferred in either direction at a full rate.

In an example, the source **501** is a source such as head unit **401**. The source **501** is coupled to the serializer **510** via cable **502**. Cable **502** is arranged to carry at least one video stream in accordance with a protocol such as the MIPI CIS.

In the example, the serializer **510** is a serializer such as multistream generator **410**. The serializer **510** includes a transmitter **590** such as transmitter **390**, which is adapted to transmit a multistream (e.g., which is generated by the serializer **510** and that includes reformatted information of the at least one video stream carried across a cable **502**), so that the deserializer **520** can receive and process (e.g., process portions of) the transmitted multistream.

In the example, the deserializer **520** is a deserializer such as stream disaggregator **420**. The deserializer **520** is coupled to the serializer **510** via cable **511**. The deserializer **520** includes a receiver **522** (such as receiver **422**) that is arranged to receive information transmitted by the transmitter **590**. The deserializer **520** includes a transmitter **526** (such as stream forwarder **426**) that is arranged to transmit information received from the transmitter **590**. Cable **511** is arranged to carry a multistream output transmitted by the transmitter **590** in accordance with a protocol such as FPD-link IV. The deserializer **520** is coupled locally to local display **504** (such as local display **404**) via cable **505**. Cable **505** is arranged to carry a selected video stream in accordance with a protocol such as eDP (extended display protocol).

In the example, the deserializer **530** is a deserializer such as stream disaggregator **430**. The deserializer **530** is coupled to the serializer **520** via cable **512**. The deserializer **530** includes a receiver **532** (such as receiver **422**) that is arranged to receive information transmitted by the transmitter **526**. The deserializer **530** includes a transmitter **536** (such as stream forwarder **426**) that is arranged to transmit information received from the transmitter **526**. Cable **512** is arranged to carry a multistream output transmitted by the transmitter **526** in accordance with a protocol such as FPD-link IV. The deserializer **530** is coupled locally to local display **506** (such as local display **406**) via cable **507**. Cable **507** is arranged to carry a selected video stream in accordance with a protocol such as eDP.

In the example, the deserializer **540** is a deserializer such as stream disaggregator **440**. The deserializer **540** is coupled to the serializer **530** via cable **513**. The deserializer **540** includes a receiver **542** (such as receiver **422**) that is arranged to receive information transmitted by the transmitter **536**. The deserializer **540** optionally includes a transmitter **546** (such as stream forwarder **426**) that is arranged to transmit information received from the transmitter **536**. Cable **513** is arranged to carry a multistream output transmitted by the transmitter **536** in accordance with a protocol such as FPD-link IV. The deserializer **540** is coupled locally to local display **508** (such as local display **408**) via cable **509**. Cable **509** is arranged to carry a selected video stream in accordance with a protocol such as eDP.

When, for example, the last deserializer in a chain only receives data intended (e.g., addressed) for display on the respective local display that is coupled locally to the last deserializer, the last deserializer need not include a switch such as switch **427**.

Modifications are possible in the described embodiments, and other embodiments are possible, within the scope of the claims.

What is claimed is:

1. A system, comprising:

a head unit adapted to generate at least two video streams;

a multistream generator coupled to the head unit, and adapted to generate encoded packets that comprise an identification field and that include information from the at least two video streams, and to couple the encoded packets to an output of the multistream generator;

a first stream disaggregator having a first stream input coupled to the output of the multistream generator, the first stream disaggregator having a first output adapted to couple in accordance with a first local protocol a received encoded packet to a first display in response to an identification field of the received encoded packet indicating a node address of the first display, and the first stream disaggregator having a second output adapted to forward the received encoded packet in response to the identification field of the received encoded packet indicating a node address of other than a first display; and

a second stream disaggregator having a second stream input coupled to the second output of the first stream disaggregator, the second stream disaggregator having a first output adapted to couple in accordance with a second local protocol the received encoded packet to a second display in response to an identification field of the received encoded packet indicating a second display node, and the second stream disaggregator having a second output adapted to forward the received encoded packet in response to an identification field of the received encoded packet indicating a node address other than a second display node address.

2. The system of claim **1**, further comprising:

a third stream disaggregator having a third stream input coupled to the second output of the second stream disaggregator, the third stream disaggregator having a first output adapted to couple the received encoded packet to a third display in response to an identification field of the received encoded packet indicating a third display node address, and the third stream disaggregator having a second output adapted to forward the received encoded packet in response to an identification field of the received encoded packet indicating a node address other than a third display node address.

3. The system of claim **1**, comprising:

a first cable coupled between the output of the multistream generator and the first stream input; and

a second cable coupled between the second output of the first stream disaggregator and the second stream disaggregator, wherein encoded packets of a first video stream are transmitted across the first cable to the first display, and wherein encoded packets of a second video stream are transmitted across the first cable and the second cable to the second display.

4. The system of claim **1**, wherein the first local protocol is a different protocol from the second local protocol.

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